(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 908 121 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
14.04.1999 Bulletin 1999/15

(51) Int. Cl.[6]: **A47C 1/00**, A47L 9/14

(21) Application number: **97830396.4**

(22) Date of filing: **28.07.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV RO SI

(71) Applicant: **CANDY S.p.A.**
I-20052 Monza (Milano) (IT)

(72) Inventor: **Fumagalli, Silvano**
20052 Monza - Milano (IT)

(74) Representative:
Perani, Aurelio et al
c/o JACOBACCI & PERANI S.p.A
Via Visconti di Modrone, 7
20122 Milano (IT)

(54) Vacuum cleaner with directly generated electrostatic effect

(57) A vacuum cleaner with an electrostatic effect, in which a suction motor unit (13) drives a frictional electrostatic generator formed by two circular rings (17, 18) of two different electrostatically chargeable materials moving relative to one another and the electrical charges of opposite sign generated are applied, respectively, to a dust container (4) and to a field plate (9, 22) housed in the container (4) and insulated therefrom, so that the electric field generated inside the container attracts and retains against the field plate and the internal wall of the container the dust particles transported by an air-flow admitted to the container.

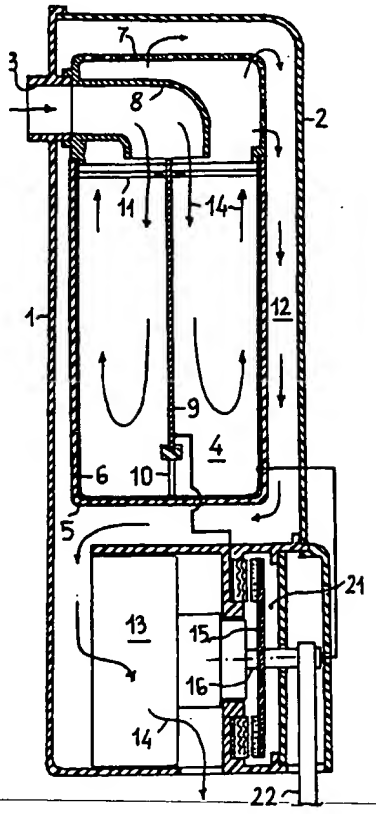

FIG. 1

EP 0 908 121 A1

Descripti n

[0001] The present invention relates to a vacuum cleaner having a dust-collection chamber with an electrostatic effect.

[0002] For household cleaning, it is known to use vacuum cleaners in which a flow of dust-laden air induced by a suction motor unit is filtered by suitable filter bags which have to be cleaned or replaced manually, creating considerable inconvenience for the user.

[0003] The bags have to be replaced periodically to ensure the efficiency of the suction system which would otherwise become clogged, and the effectiveness of the filter which, in any case, does not constitute a barrier capable of retaining the finest dust particles.

[0004] These pass through the filter barrier and, to a certain extent, are readmitted to the environment with effects which may be damaging to health.

[0005] The requirements of today's market, which is ever more sensitive to problems of allergic reactions resulting from the presence of dust, pollens and mites, force the product to ever more extreme (efficacious) filtration levels with complex and expensive devices having multiple filtering layers, microfilters, and activated-carbon filters which create very high vacuum losses in the suction flow considerably increasing the suction power required, as well as power consumption.

[0006] In order to overcome at least some of these problems, as an alternative system, vacuum cleaners with single cyclones or with multiple cyclones in cascade, in which the dust is captured by a centrifugal effect, have been proposed.

[0007] These vacuum cleaners are more efficient, require a lower and relatively constant suction power in operation (and do not include filters which may become clogged) but they do not solve the problem of capturing the finest particles of low density which, to a certain extent, are dispersed again.

[0008] Finally, they have no neutralizing effect on the bacterial charge of the dust or on mites which, owing to their size, are dispersed into the atmosphere again.

[0009] The use of electrostatic filters for electrical household appliances has also recently been proposed; these filters are intrinsically able to capture even the finest particles and, owing to the intense electrical fields generated, effectively neutralize mites and bacteria so that, even if only some of them are captured, they are in any case neutralized.

[0010] However, with these vacuum cleaners, there is the problem of supplying them with extremely high electrical voltages, and at the same time ensuring the user's safety.

[0011] To solve this problem, it has been proposed, for example, in the document EP-A-0578365, to create intense local electric fields with relatively low supply voltages with the use of conductive mesh nets electrically insulated from one another and disposed very close together.

[0012] Even with low voltages of the order of tens of volts, it is possible to generate local electric fields which are effective for capturing th finest dust.

[0013] However, this solution again raises the problem of clogging of the filter and, no less importantly, also of its cleaning.

[0014] The present invention solves this problem and provides a household vacuum cleaner with an electrostatic effect which is safe in operation, efficient, easy to clean, particularly effective in capturing the finest particles and in neutralizing the bacterial flora and mites, in which the field charge is generated by a tribo-electric effect by means of a rotary disk keyed to the motor shaft of the suction motor unit, and in which the electrical charges of opposite sign generated are applied to a container for collecting the particles and to a field plate housed in the container, respectively.

[0015] Since, owing to its nature, the electrostatic generator is a voltage generator with a very high internal impedance, the electrical power output is extremely low and such as not to involve any danger to the user, even in running conditions.

[0016] Moreover, its activation and de-activation are automatic because they are dependent on the rotation of the motor so that the maintenance and cleaning/emptying of the container, which are necessarily carried out with the vacuum cleaner switched off, can be performed in conditions of absolute safety, possibly further guaranteed by the use of high-impedance dischargers connecting the container to its internal field plate which is charged with a polarity of opposite sign and faces the walls of the container with which it forms a capacitor.

[0017] Since the electrical capacitance of the capacitor structure thus formed is extremely low, the capacitor can be charged with a high voltage in a very short time, of the order of one second, even though the impedance of the generator is high.

[0018] Similarly, when the electrostatic generator is inactive, the capacitor is discharged extremely quickly both owing to the ionization of the air brought about by the electric field, and by a high-impedance discharger, if one is provided.

[0019] The characteristics and advantages of the present invention will become clearer from the following description of a preferred embodiment and of variants thereof, given with reference to the appended drawings, in which:

- Figure 1 is a schematic, vertical section of a preferred embodiment of a vacuum cleaner according to the present invention,
- Figure 2 is an enlarged view of a structural detail of the vacuum cleaner of Figure 1, in particular of its electrostatic generator,
- Figure 3 is a schematic, vertical section of a variant of the vacuum cleaner of Figure 1,
- Figure 4 is a partially-sectioned side view of a further variant of the vacuum cleaner according to the

present invention.

[0020] With reference to Figure 1, this is a schematic section showing a domestic vacuum cleaner comprising an outer shell 1 of plastics material, closed by a removable lid 2, also of plastics material.

[0021] A union 3 for connection to a suction hose, not shown, opens in the shell 1.

[0022] The upper portion of the shell 1 houses a generally beaker-shaped dust-collection container 4 with a rectangular or even rounded cross-section, according to the shape of the shell 1 and of the lid 2.

[0023] The container 4 is preferably but not necessarily constituted by an outer beaker-shaped element 5 of insulating plastics material coupled to an inner beaker-shaped element 6 of a conductive material.

[0024] Alternatively, the inner beaker-shaped element 6 may consist of metallization on the internal surface of the container, produced by one of the various usual metallization techniques (spraying, electrical deposition, or the like).

[0025] A further alternative may be constituted by the elimination of the outer plastics beaker-shaped element and by the treatment of the outer surface of the beaker-shaped element of conductive material by painting or plastics-coating, essentially for aesthetic purposes.

[0026] The container 4 is closed at the top by a removable lid 7 with gratings for the passage of an air-flow.

[0027] Inside the lid 7 there is a suction elbow 8 which is connected to the union 3 and is oriented towards the container 4.

[0028] The lid 7 and the suction elbow are advantageously produced by moulding or blowing of plastics material.

[0029] The container 4 houses a metal plate 9 advantageously spaced from the container 4 by suitable insulating support spacers 10, 11.

[0030] Between the container 4 and its lid 7, on the one hand, and the outer shell 1 and the lid 2 on the other hand, there is a space 12 for the passage of an air-flow coming from inside the lid 7.

[0031] Below the container 4, the shell 1 houses a suction motor unit 13 which draws the air from the space 12 and conveys it out of the shell.

[0032] Activation of the suction motor unit 13 thus induces an air-flow which enters through the union 3, passes through the elbow 8, and over the plate 9, and rises from the container 4 again towards the lid 7, passing along the walls of the container and flowing out through the space 12 and the suction motor unit 13.

[0033] The path followed by the air-flow is indicated by the arrows 14.

[0034] Some of the solid particles transported by the air-flow entering through the union 3 (the fraction with larger dimensions and greater specific weight) are deposited in the container 4 by gravity and also owing to the reduction in the speed of the air-flow in th container because the cross-section of the container is larger than outlet cross-section of the suction hose.

[0035] The finer and lighter particles, on the other hand, are captured owing to the electric field generated inside the container 4 by the applicati n of a high voltage of the order of 10 kV or even more between the plate 9 and the inner beaker-shaped element 6 of the container 4.

[0036] The voltage generator used is an electrostatic generator constituted by a rotary disk 15 keyed to the shaft 16 of the suction motor unit.

[0037] The disk of conductive material carries, on a circular surface 17, a suitable material, for example, a woollen felt or brush, disposed beside a fixed circular surface 18 of another suitable material different from that of the surface 17, for example, of Teflon or another synthetic fibre.

[0038] The fixed surface 18 is supported by a conductive plate 19 which in turn is housed in an insulating support 20 formed by the shell 1 or fixed thereto.

[0039] Figure 2 is a cross-sectional detail, on an enlarged scale, showing these components more clearly.

[0040] As shown in Figure 2, the two surfaces 17 and 18 may be spaced apart slightly or may even be in contact with one another.

[0041] The distance D between the rotary disk 15 and the fixed plate 19 advantageously depends on the two tribo-electric materials of the two facing surfaces and, by way of indication, may be of the order of 10 mm or even more.

[0042] The disk 15 may be rigid or flexible and may even be constituted by an array of radially projecting blades.

[0043] This structure is enclosed, for safety and protection against the introduction of foreign bodies, in a box 21 of insulating plastics material (Figure 1).

[0044] In vacuum cleaners with combined brushing or polishing functions, the motor shaft 16 may extend outside the box 21 to form a kinematic coupling (for example, by means of a belt 22) with the rotary brushes.

[0045] The motor shaft 16 and the plate 19 are in electrical connection, respectively, with one and with the other of the two metal elements constituted by the plate 9 and by the beaker-shaped element 6.

[0046] When the suction motor unit is supplied with power, the shaft 16 and the disk 15 keyed thereto rotate at high speed (20,000 revolutions/minute and in some vacuum cleaners even up to 40,000 revolutions/minute).

[0047] Owing to the relative movement between the surfaces 17 and 19, electrical charges of opposite signs (the sign depends on the materials used) accumulate on the disk 15 and on the plate 19 and a high electrical voltage (10-20 kV) is developed and is applied between the plate 9 and the beaker-shaped element 6.

[0048] An electric field with a high gradient of the order of some kV/cm (depending on the distance of the plate 9 fr m the beaker-shaped element 6 and on their shapes) is thus developed between the plate 9 and the

beaker-shaped element 6.

[0049] This lectric field has the effect of polarizing the finest dust particles by dielectric induction if they are not already charged electrically owing to a tribo-electric effect in the turbulent air-flow.

[0050] The particles thus polarized are therefore drawn either to the plate 9 or to the inside wall of the beaker-shaped element 6, where they are deposited.

[0051] When the vacuum cleaner is switched off, the electric field disappears rapidly owing to dispersion of the electric charge and the dust is detached from the walls and falls to the bottom of the container 4.

[0052] The power which is developed by the electrostatic generator and which is necessary to charge the metal plates and keep them charged is extremely low, of the order of a few mW and the system is therefore intrinsically safe.

[0053] Even in the event of accidental contact with the electrically-charged conductive parts, the resulting electric arc can cause only a certain nuisance which, in any case, is much less than that caused by the electrostatic charge which forms, for example, on dry days, on insulating bodies such as motor-cars, the capacitance of which is much greater than that of the structure described.

[0054] This risk can be eliminated completely by the housing of the electrically-charged conductive parts inside an insulating protective body such as the shell 1 and the lid 2.

[0055] Devices such as very simple and inexpensive field gradient dischargers operated by the opening of the lid 2 may be provided for short-circuiting the beaker-shaped element 6 and the plate 9 to ensure that the voltage applied does not exceed a predetermined value.

[0056] In order to empty the solid particles from the container 4, it suffices to switch off the vacuum cleaner, open the lid 2 and remove the container 4 with its lid 7 from the shell 1, and then remove the lid 7 and empty out the contents of the container.

[0057] It is interesting to note that, in order to empty the container, it is possible to fit a refuse bag over its mouth and then invert it in order to prevent any dispersal of dust.

[0058] Even in the absence of auxiliary filters, the capturing efficiency of a vacuum cleaner as described is very high, even for very fine particles.

[0059] The foregoing description relates purely to an embodiment which is preferred owing to its simplicity, but clearly many variations may be applied.

[0060] In particular, it is clear that by appropriate selection of the pair of electrostatic materials, of the distance between the two rings of electrostatic material and of the distance between the plate 19 and the disk 15, all of which parameters can be varied within a very wide range, it is possible to achieve the optimal electrostatic effect for various applications in terms both of the voltage generated and of th electrical power utput.

[0061] Moreover, the structure of the container with a central plate for generating the electric field may clearly be replaced by other structures.

[0062] Figure 3 shows, by way of example, a variant of the vacuum cleaner of Figure 1 in which the plate 9 has been replaced by a beaker-shaped element 122 having a plurality of through-holes, or even made of a metallic mesh.

[0063] The beaker-shaped element 122 is housed in the container 4 at a suitable distance from the internal wall thereof and has an upper inlet opening connected to the output of the elbow 8.

[0064] The dusty air enters the beaker-shaped element 122 where the coarser particles accumulate and then passes through the holes in the beaker-shaped element 122 into the container 4 in order to flow out through its lid 7 as in the embodiment of Figure 1.

[0065] It is possible, with suitable dimensions of the beaker-shaped element 122 relative to the container 4, to achieve a particularly intense and uniform electric field in the space between the beaker-shaped element 122 and the container 4, enhancing its effectiveness.

[0066] The dust is deposited on the outer surface of the beaker-shaped element 122 and on the inner surface of the container 4.

[0067] A further increase in efficiency can be achieved by the use of multiple beaker-shaped elements housed inside one another, alternate elements being connected to the positive and negative poles of the voltage generator; this measure increases the surface on which the dust can be deposited but makes the cleaning of the container 4 and of the various beaker-shaped elements more laborious.

[0068] As a further variant, the electrostatic generator of Figure 1 may be replaced by a battery of electrostatic generators.

[0069] In Figure 3, a rotary disk 23, in this case made of insulating material with a single peripheral conductive ring, keyed to the motor shaft, has on the two faces of the conductive ring, two surfaces 24, 25 of different electrostatic material such as wool and synthetic fibre.

[0070] The two surfaces 24, 25 are juxtaposed in contact with or close to two fixed surfaces 16, 17 of electrostatic materials different from those of the juxtaposed surfaces.

[0071] Finally, the two fixed surfaces 26, 27 are coupled to two metallic collector plates 28, 29 electrically connected, respectively, to the beaker-shaped element 22 and to the container 4, which is formed, for example, of metal painted externally for purely aesthetic purposes.

[0072] In Figures 1 and 3, the vacuum cleaner is of the upright type for use in a substantially vertical position.

[0073] Unlike cyclone vacuum cleaners, the electrostatic capture system described can, however, also be used in vacuum cleaners with horizontal structures.

[0074] In fact a minimal inclination of the container suffices to enable the solid particles to accumulate on its lower wall.

[0075] Figure 4 shows, by way of example, in a partially-sectioned side view, a compact vacuum cleaner 30 mounted on a pair of rear wheels 31 and on a swivelling front wh el 32.

[0076] The front portion of the vacuum cleaner houses a cylindrical or even prismatic container 33 with a slightly inclined axis.

[0077] The container houses a perforated beaker-shaped element 34, the mouth of which is connected to an inlet union 35 for air drawn in.

[0078] The shell of the vacuum cleaner, with a lid which can be opened in order to remove the container 33, forms a space which conveys the air drawn in towards a suction motor unit 36 which drives an electrostatic generator 37 of the type already described.

[0079] When the vacuum cleaner is in operation, the dust adheres to the internal wall of the container without being transported by the relatively low-speed output air-flow.

[0080] When the vacuum cleaner is switched off and the electric field disappears, the dust in any case falls into the container, even if it is in an almost horizontal position, as shown.

Claims

1. An electrical appliance such as a vacuum cleaner, electric sweeper, or the like with an electrostatic effect, comprising a suction motor unit (13) for generating an air-flow which is drawn in through a suction union (3), and a particle-collection container (4) in communication with the union (3), characterized in that the vacuum cleaner also comprises a frictional electrostatic generator (15, 17, 18 19) driven by the suction motor unit (13) and having two conductive plates (15, 19) for collecting electrical charges of opposite signs generated by the electrostatic generator, in that the container (4) is made of conductive material and is electrically connected to one (19) of the two plates, and in that the container (4) houses a third conductive field plate (9, 22) electrically insulated from the container and electrically connected to the other (15) of the two plates.

2. An electrical appliance according to Claim 1, in which the third plate (9) is a metal plate.

3. An electrical appliance according to Claim 1, in which the third plate is constituted by a beaker-shaped element (22) with openings for the passage of air and an inlet opening connected to the suction union (3).

4. An electrical appliance according to the preceding claims, comprising a removable container lid (7) with openings for the passage of air, housing a suction elbow (8) connected to the union (3), and an outer shell (1, 2) of insulating material for housing the container (4) and the container lid (7) forming a space between the container (4) and the shell (1, 2) for conveying the air flowing out of th lid (7) into the space towards the suction motor unit (13).

5. An electrical appliance according to the preceding claims, in which the electrostatic generator comprises a conductive disk (15) keyed to the shaft of the suction motor unit (13) and forming one of the two plates, the disk being coupled to a first circular felt or brush ring (18) of a first electrostatically chargeable material, which is juxtaposed with a second circular felt or brush ring (18) of a second electrostatically chargeable material different from the first, coupled to the other (19) of the two plates, the other plate being fixed in the appliance.

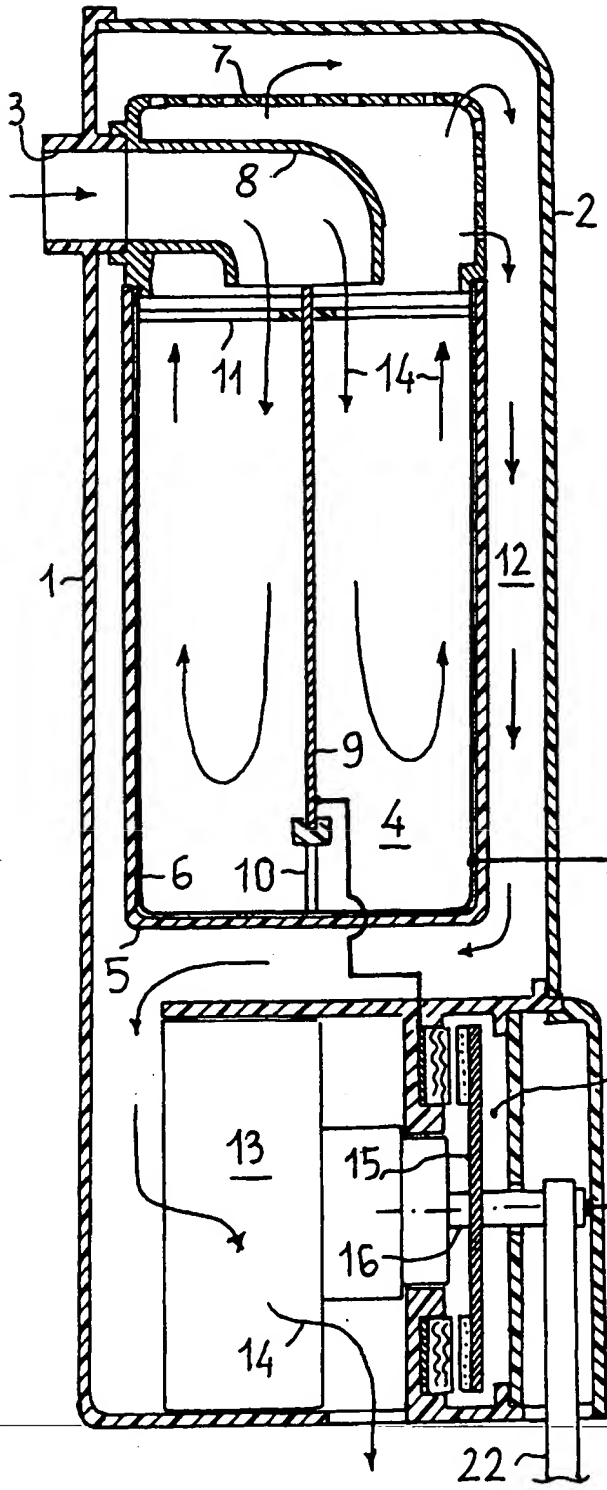

FIG. 1

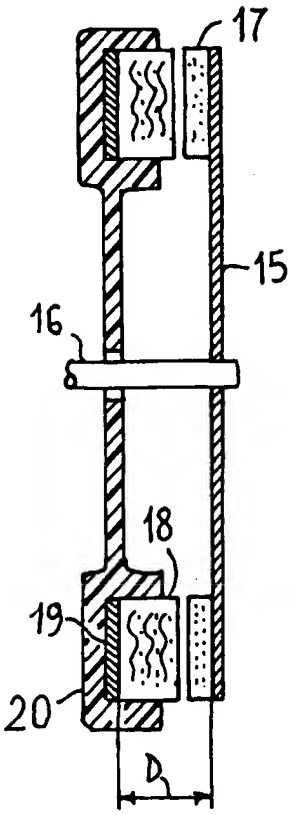

FIG. 2

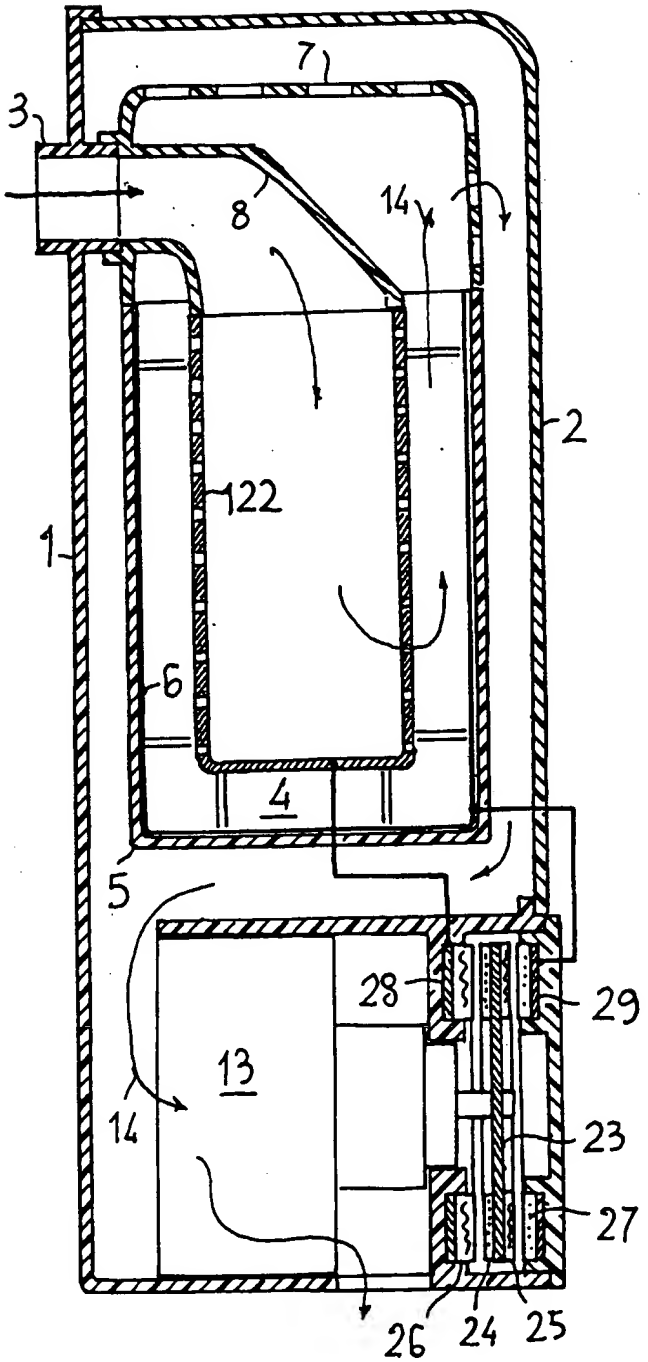

FIG. 3

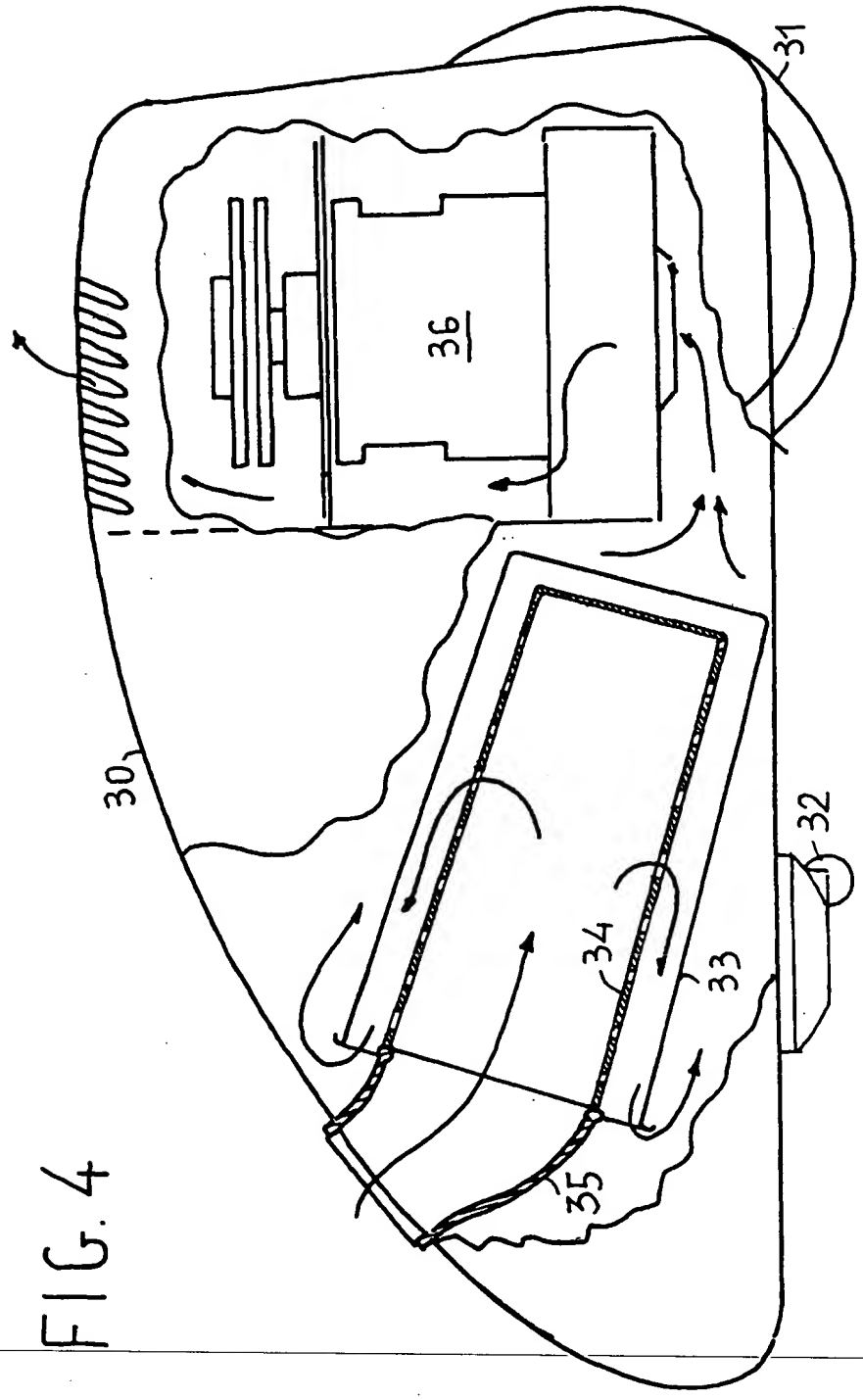

FIG. 4

European Patent Office

EUROPEAN SEARCH REP RT

Application Number
EP 97 83 0396

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US 5 400 465 A (BOSSES ET AL) * column 4, line 9 - line 65; figures 1-5 * ---	1	A47C1/00 A47L9/14
A	DE 31 43 489 A (VOLKRODT) ---		
A	US 4 186 030 A (ARMSTRONG) ---		
D,A	EP 0 578 365 A (THE SCOTT FETZER COMPANY) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

A47L
H02N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 March 1998	VAN GELDER, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)